THE PLUM CURCULIO ON PEACHES

AND

ITS CONTROL

By
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STATE COLLEGE OF AGRICULTURE AND ENGINEERING
U. S. DEPARTMENT OF AGRICULTURE
and
N. C. DEPARTMENT OF AGRICULTURE, COOPERATING

Cooperative Extension Work in Agriculture
and Home Economics

N. C. AGRICULTURAL EXTENSION SERVICE
B. W. KILGORE, Director
RALEIGH

STRIBUTED IN FURTHERANCE OF THE ACTS OF CONGRESS OF MAY 8 AND JUNE 30, 1914

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The plum curculio† is one of the most destructive and difficult enem to control on peach trees in North Carolina. This pest became so se ous in the commercial peach belt in the sandhills in 1921 that St and Federal aid was requested by the growers to study the insect and instruct peach growers in the methods of its control. Accordingly, study of the life-history, habits, and control of the curculio was ma during the years 1922 and 1923, at a field laboratory located at Ab deen. The control measures previously found effective in Georgia Federal workers of the Bureau of Entomology were correlated with t life-history of the insect as ascertained in the sandhills, and carried o by the commercial peach growers with success.

This circular* is prepared for the benefit of the owner of the hon peach orchard, as well as the commercial orchard, for the control mea ures will apply equally well in either case. One application of spray dust, and the picking-up of dropped fruit, is advised, in addition to t recommendations suggested by the Division of Entomology prior to 192 The spray or dust application is to be made just after the petals fa and the drops are to be picked up during April and May. The hon orchard owner who is not familiar with these present recommendatio will find these additional orchard practices of considerable value in co trolling the curculio.

LIFE-HISTORY AND HABITS

The plum curculio is a hard snout beetle, measuring about thre eighths of an inch in length. This beetle is the parent of the crea colored legless grub or "worm," familiar to all peach growers, that found in the small dropped fruit, or in ripening peaches next to the pi

† *Conotrachelus nenuphar.*

* This circular contains much of what has been previously issued in the Bu letin of the North Carolina Department of Agriculture for March, 1923, e titled "The Plum Curculio on Peaches in North Carolina, Its Life-History an Control," by R. W. Leiby and John B. Gill, the data of which was based o work done by these writers in 1922. The general account of the life-history i the present circular also includes some of the additional field and laborato studies made by R. W. Leiby and J. A. Harris during 1923. The results of th field-control tests conducted by the present writers in 1923 are also summa rized in the recommendations for control.

During 1922 this project was supported coöperatively by the Bureau Entomology of the United States Department of Agriculture and the Divisio of Entomology of the North Carolina State College and Department of Agr culture, the Federal Bureau being represented by Mr. Gill and the State b Dr. Leiby. In 1923 the project was supported solely by the State.

re its feeding has caused the infested fruit to be worthless. In h Carolina this insect is known also to attack cultivated plums, es, cherries, and wild plums, the latter probably being its native plant.

his insect, like other beetles, passes through four stages in developing mplete generation—the egg, which is laid by the parent beetle under kin of the fruit; the worm, which hatches from the egg and develops he flesh of the fruit; the pupa or resting stage, which is passed in a l earthen cell in the soil; and the adult or beetle stage, which de- ps from the pupal stage.

FIG. 1. Adult curculio on young peach. Enlarged two and one-half times. (Original.)

Where the curculios pass the winter and when they enter the orchard. e adult curculios spend the winter in the woods which are near or t to the orchard, presumably under leaves or in tufts of grass, and in ilarly suitable places in the orchard. This has been determined by fact that the side of the orchard next to the woods or waste lands is ays more heavily infested in spring than the other parts of the hard which are not so located. Similarly the infestation is frequently vier around buildings in the orchard.

Most of the beetles leave their winter quarters and fly to the orchard ly in spring, while others reach the orchard as late as the middle of y. Thus the first beetle was taken in the orchard in 1922, on March

27, and on March 26 in 1923. A very large percentage of the beet enter the orchard during the week that the shucks of the young peac are being shed.

Feeding and egg-laying. Upon arriving in the orchard the beet first feed upon the unfolding leaves and green shucks of the blooms; a while the shucks are being shed, they feed upon the young fruit. Duri this period the beetles mate.

In feeding upon the fruit, two kinds of punctures are made—the c cular one being usually a feeding puncture only, while the crescen puncture usually indicates that an egg has been laid in the feedi

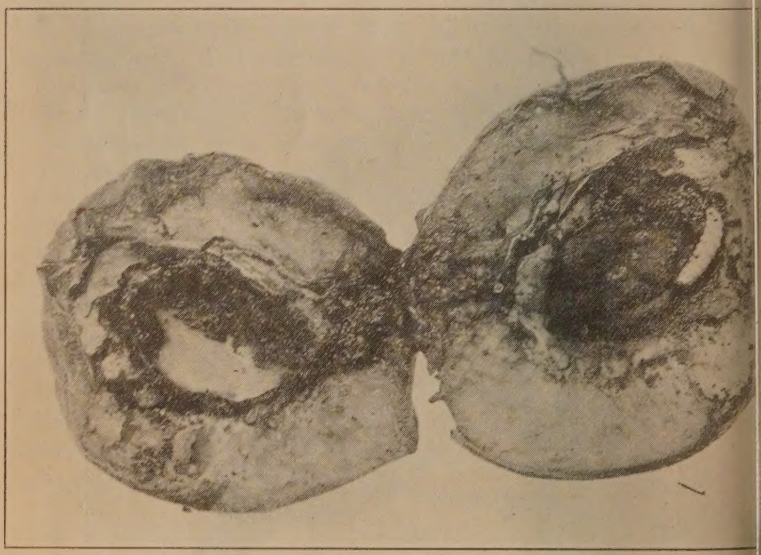


Fig. 2. Peach split open to show the curculio worm and the result of its feeding. Enlarged twice. (Original.)

puncture, under the crescentic cut. In laying an egg in a young peac the female first cuts through the pubescence of the fruit and eats out small cavity under the skin. She then turns about and inserts a minu colorless egg into the hole. A crescentic-shaped slit is then cut in fro of, and underneath the egg, which leaves the egg in the fleshy flap the fruit. However, eggs are frequently placed in simple circular pun tures, made directly under the pubescence of the small peach.

Our studies of 1922 and 1923 show that a very large percentage of t eggs are laid within ten days or two weeks after the shucks are she The eggs hatch in from four to five days.

Development of the spring brood of larvæ and emergence of beetl from the soil. Upon hatching from the egg, the minute white worn

FIG. 3. Adult curculio resting on peach. A typical crescent egg puncture is shown on the peach above. Enlarged about two and one-half times. (Original.)

G. 4. Peach drop with two eggs of the curculio exposed. Eggs are indicated by arrows. Enlarged about four times. (Original.)

bore into and feed upon the flesh of the young fruits. Continued f ing causes the infested fruit to become discolored, somewhat shrun and finally to drop. The worms become fully grown in about sixte eighteen days, whereupon they emerge from the fallen fruits and bur into the soil. At a depth of three or four inches in loose, sandy soil, e worm forms a small oval cell with the aid of its body, in which it tr forms to the pupal and later the adult stage. Where the soil is n compact, and seldom or never disturbed, the earthen cell is made depth of only one or two inches.

The insect spends approximately a total of thirty days in the grou in the worm, pupal, and adult stages. Of the thirty-day period, ab fourteen days are passed in the worm stage, twelve days in the pu stage, and four or five days in the beetle stage.

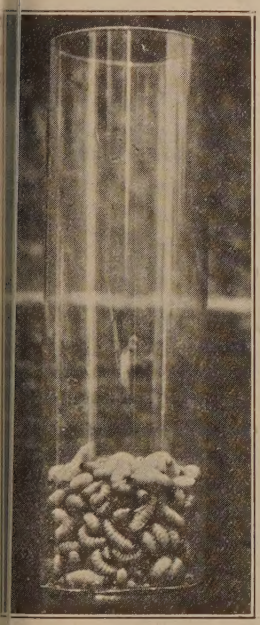
Fig. 5. Adult curculio on leaf stem eating holes in leaf. Enlarged twice. (Original.)

During 1922, 63 per cent of the beetles of this brood emerged fr the soil between June 9 and 12. In 1923, owing to a cooler and la season, the majority of the first brood of beetles emerged between Ju 16 and 23, or about a week later than in 1922. About the middle June, therefore, the beetles in the orchard consist of newly emerg first-brood beetles and some surviving beetles of the overwintering g eration.

*Summer egg-laying in late varieties of peaches.** After the beetles the spring brood emerge, they feed upon the fruit in the orchard. T insectary investigations show that in 1922 only about 20 per cent of t

* In the sandhill section of North Carolina the varieties ripening previ to Carman are known as early varieties. Carman, Slappey, and Hiley midseason varieties, while Belle, Elberta, and Hale are late-season varieti The terms early, mid- and late-season are here used to include the variet mentioned in their respective categories above.

ale beetles of the spring brood laid eggs, while in 1923 only about 10 cent of the females deposited eggs. It is the combined egg-laying he surviving overwintering beetles and the spring brood of beetles, ipening and midseason varieties, and late varieties that have passed ough the stone-hardening period, that is responsible for the develop- t of a summer brood* of worms and adults; the worms emerging in abers from the fruit at the time that the Belle and Elberta varieties ripening, or about twenty days after the eggs are laid.



. 6. Vial containing 237 rms collected one morning m a bushel of drops. About 00 such worms were bred m a bushel of drops. Natural size. (Original.)

Emergence and habits of summer brood adults. The worms that emerge from the late-ripening varieties burrow into the soil and transform to beetles exactly as do the spring brood of worms. About thirty-one days later the beetles emerge from the soil. By this time all the commercial varieties of fruit are harvested, whereupon the beetles feed upon the foliage or any scattered fruit that may remain upon the trees.

About September 1 the beetles in the orchard represent largely first- and second-brood adults, although there may be a scattering few survivors of the overwintering generation. At the approach of cold weather the beetles migrate from the orchard to the woods or to suitable wintering places, from which they emerge the following spring.

NATURAL ENEMIES OF THE CURCULIO

Two kinds of insect enemies or parasites prey upon the worm stage of the curculio in this State. One is a small, wasp-like insect, known as *Triaspis curculionis* Fitch; the other is a true fly, known as *Myophasia globosa* Twnsd. The former species was reared in June of 1922 and 1923, the latter year in sufficient numbers so that it may be garded as of some value in the natural control of the curculio. *Myo- asia globosa* was reared in late July and early August, 1922, and in ly of 1923. This species is less important.

Ants are undoubtedly of value in reducing the number of curculios hunting the worms in the soil and devouring them.

* This second brood is termed the summer brood in this circular because it developed during the period of July and August.

RECOMMENDATIONS FOR CONTROL

Our experience in this State during the past two years has shown th in order to grow peaches reasonably free from curculio on a commerc scale, it is necessary to practise several control measures systematical These control measures extend throughout the growing season and co sist of (1) orchard sanitation, (2) four applications of spray or du mixtures, (3) picking-up of dropped fruit, and (4) cultivation. Whe the fruit is not grown for sale, such as in the small home orchard, cul vation and orchard sanitation need not be practised, although a failu to carry out these two control measures will mean more wormy fruit.

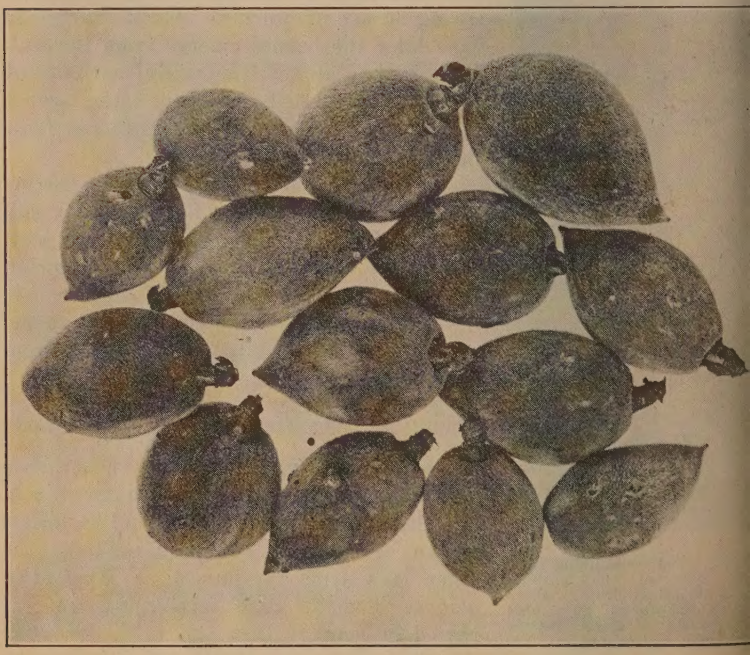


Fig. 7. Young peaches which have been stung by the curculio. Fruits like this fall and should be picked up. Slightly enlarged. (Original.)

The commercial peach grower of the sandhill section of North Caroli knows that in 1922 and 1923 the cleanest fruit was grown in tho orchards in which the owners carried out all four control operatio diligently. Growers who neglected one or more of these operations, were careless in carrying them out, suffered curculio injury proportio ately. Failure in complete control—that is, having more than one three per cent of wormy fruit—may be due, among other things, to

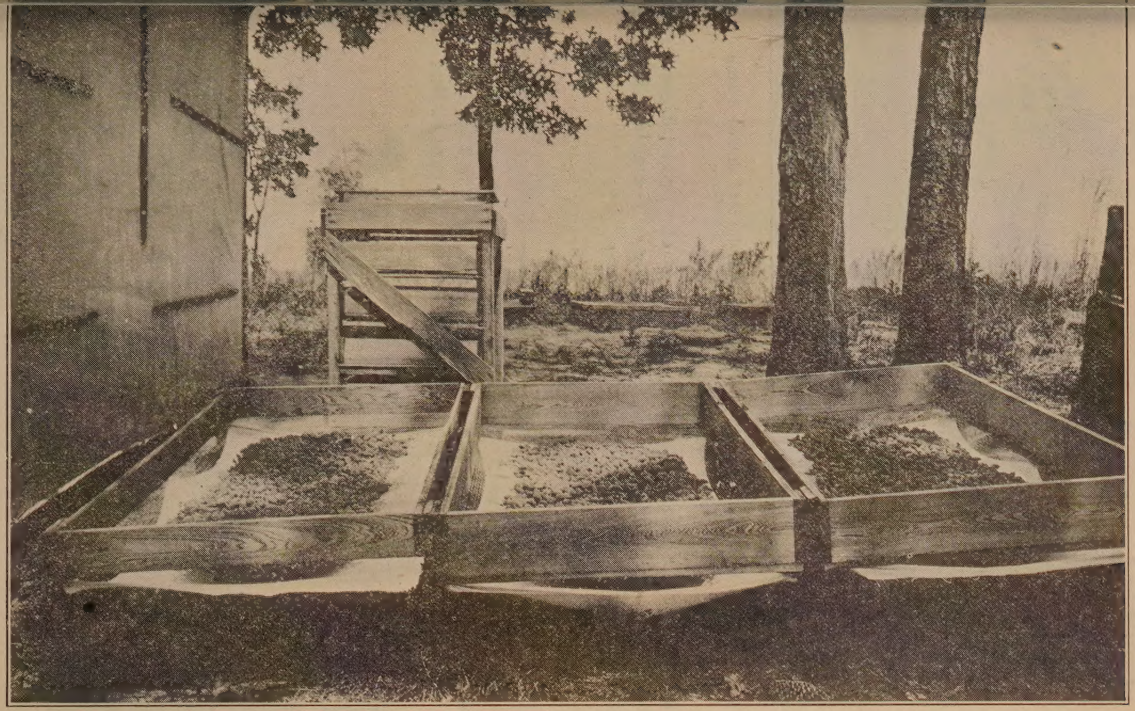


FIG. 8. View of insectary and breeding cages. In the trays shown above the worms emerge from the drops when mature and fall on the sheets through the wire screen. The worms and drops are counted to ascertain the percentage of infestation. Worms are then put in ground cages to raise to the adult curculio stage. Aberdeen, North Carolina, 1923. (Original.)

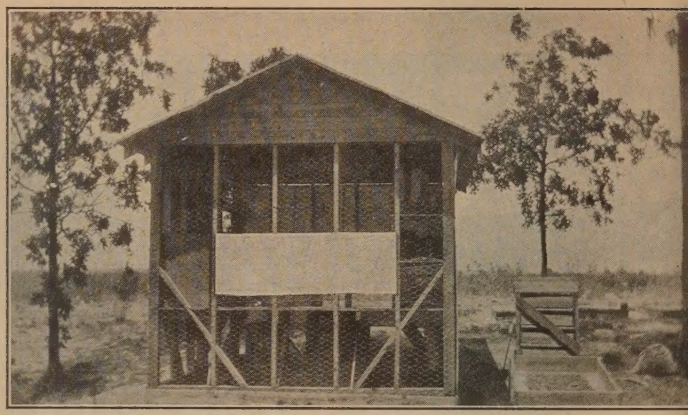


Fig. 9. Insectary where life-history of the curculio was studied during 1922 and 1923. Aberdeen, North Carolina.

spray or dust application not being made at the proper time (par larly the first two sprays or dusts), changing of formulas of the s mixtures, and careless picking-up of the drops.

Orchard Sanitation

By orchard sanitation we mean burning over the edges of the orch and within the orchards, during late February or early March, waste lands that contain rubbish, leaves, etc., which afford shelte the adult beetles during the winter. If the beetles cannot find sui

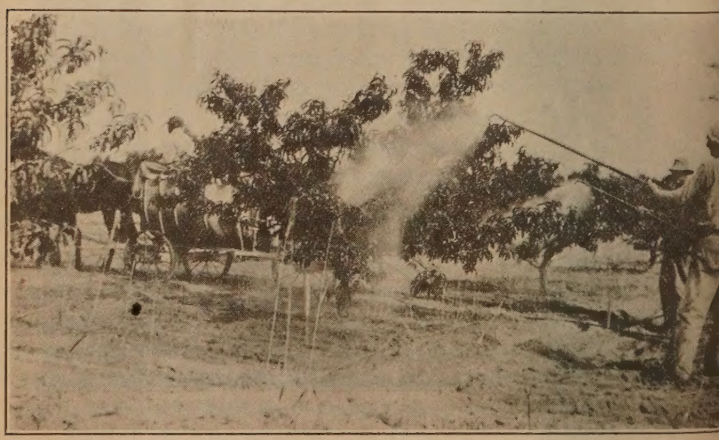


Fig. 10. Spraying in a sandhill peach orchard. Hoffman Farms, Hoffman, N. C.,

FIG. 11. Orchard dusting machine in operation in the sandhills. Marston, N. C., 1923.

winter quarters in the orchard in late summer or early fall, they w travel to the woods that may be as far as two hundred yards from orchard. But the greater the distance they must travel to find a win hiding-place, the greater are the hazards for their successful return to the orchard in spring.

Our experiments in burning over waste lands next to the orchard, learn whether the burning destroys some of the curculios in their win quarters, indicate the advisability of this practise, at least from standpoint of curculio control. Thus, in 1922 we collected 62 per c less beetles on a block of forty-four trees which were opposite a part the woods that was burned over, than we collected on a similar block forty-four trees located opposite a part of the same woods which was burned over. A similar result, but on a smaller scale, was demonstra during the spring of 1923.

The burning must be done thoroughly, and this means that the gra weeds, and leaves must be thoroughly dry; otherwise, the fire will burn close to the ground, and a higher percentage of the beetles w escape the burn. The grower will find, too, that a thorough burning almost impossible when practised two successive years. For the seco year there is less vegetation to burn; the fire will skip and must be c ried from place to place.

Precautions in burning are, of course, necessary and essential. should never be done without competent supervision and sufficient lab to cope with any emergency that may arise. As a rule, the commerci peach-grower in our sandhills understands this, for during the yea 1922 and 1923 no damage to trees or buildings has been reported fro fires started to control the curculio.

Spraying and Dusting Applications

Four applications of a spray or dust are recommended for the peac growing season to poison the adult curculios and to control brown r and scab. The latter two diseases are apparently not a serious fact to peaches in the sandhills; but our examinations of properly spray or dusted fruit, made during 1922 and 1923, show that the small pe centage of unsprayed fruit affected by these diseases is almost entire eliminated by the four-spray or dust schedule. The greater prevalen of brown rot and scab in the home orchard is probably due to carele ness or lack of treatment over a period of years. This is indicated the total absence of brown rot and scab in regularly sprayed commerci orchards. It should be remembered that the sulphur in the dust a spray formulas is the important element in the control of these t diseases.

According to our present knowledge and past experience, all varieti ripening later than Carman should receive all four applications of t spray or dust schedules given below, although some growers prefer

e the fourth application on Carman as well. Varieties ripening re Carman need only three applications, which should be made at *times* recommended in the schedules for the first, second, and fourth ications; but in the case of spraying, the materials and formulas in these three sprays should be those which are called for in the , third, and fourth treatments. The difference is, that the self- d lime-sulphur is required in the third treatment of the four-spray dule, whereas in the second treatment the sulphur is omitted. The e dusting formula is used for all treatments, because it is usually hased already mixed.

SPRAYING SCHEDULE

application. Immediately after the petals fall, use one pound of pow- dered arsenate of lead, plus lime water in which 3 pounds of good stone lime has been slaked, to each 50 gallons of water.

nd application. When the calyces or shucks are shedding, which is about en days after the falling of the petals, use the same spray as for the first application.

d application. Two weeks after the second application, or about four weeks after the petals have fallen, use one pound of powdered arsenate of lead with each 50 gallons of 8-8-50 self-boiled lime-sulphur.

rth application. About four weeks before each variety is due to ripen, use the same spray as recommended for third application.

1922 the above-described schedule which was used in our experi- ts reduced the amount of wormy fruit from 37.7 per cent in an prayed block of seven-year-old Elberta trees to 6.13 per cent in the ayed block. In 1923 similar experiments on Georgia Belle variety ved a reduction of wormy fruit from 30.7 per cent in the unsprayed k to 1.17 per cent in the sprayed block. It is evident, therefore, thorough and careful spraying is effective in the control of the ulio.

DUSTING SCHEDULE

80-5-15 mixture, composed of 80 per cent sulphur, 5 per cent arsenate of lead and 15 per cent hydrated lime, is recommended for dusting. The applications should be made at the same times that the spray applications are recommended, the same dusting formula being used for all dust appli- cations. The times for dusting applications are: first, immediately after the petals have fallen; second, when the calyces or shucks are shedding; third, two weeks after the second application; fourth, about four weeks before each variety is due to ripen.

our treatments with the dust mixture mentioned above, and applied ng 1922 and 1923, reduced the percentage of curculio-infested fruit 37 to 30 per cent, respectively, on untreated trees to 5.7 and 3.3 per , respectively, on dusted trees. The control by dusting was better on trees sprayed four times in 1922, and not quite as good as that prayed trees in 1923. Success by either method will depend largely thoroughness and equal distribution of materials.

There is a recent tendency among some of the commercial p
growers who dust to return to the use of the 80-10-10 formula of
dusting mixture used prior to 1922 with apparently very good re
and little or no burning of foliage. The 80-10-10 formula contains
more parts per hundred of lead arsenate and five less parts of lime,
it is argued that the extra five parts of lead arsenate will effect ev
better control of the curculio. It appears to the writers that a mix
containing 80 parts of sulphur, 7 parts of arsenate of lead and 13 p
of lime would be safer to use. We understand that this formula of
mixture is now available to the growers.

Directions for Preparing Spray Mixtures

Lead-lime-water mixture. Slake three pounds of stone lime in a small q
tity of water and dilute to 50 gallons. Mix one pound of powd
arsenate of lead in a small quantity of water and add to the lime mixt
Agitate thoroughly before applying.

Self-boiled lime-sulphur mixture. The 8-8-50 self-boiled lime-sulphur mix
is composed of 8 pounds of good stone lime, 8 pounds of sulphur and
gallons of water. Any finely powdered sulphur (flowers, flour, or "c
mercial-ground" sulphur) may be used in the mixture. The formula
be raised to 16-16-100, or 32-32-200 to meet the capacity requirements
the spray tank. The amounts used in the following directions are fo
200-gallon tank:

Place 32 pounds of lime in a 50-gallon barrel and pour on enough w
to start slaking. As soon as the lime begins to slake, 32 pounds of sulp
should be added; the lumps of sulphur, if present, having been previo
broken up. Add water from time to time to keep the mixture from
coming dry, but be careful not to drown the lime, as this will cause
mixture to cease boiling. The mixture should be stirred constantly. A
the mixture has boiled about five minutes, cool with water to prevent
ther cooking. The mixture is then ready to be strained into the sp
tank and diluted to 200 gallons. Precautions should be taken to cool
mixture with water before the red streaks appear to any extent in
mixture; on the other hand, the mixture must not be cooled before
boiling has progressed sufficiently.

The required amount of arsenate of lead should be mixed separately
a small quantity of water, and this mixture then added to the self-boi
lime-sulphur mixture in the spray tank, when a poison is called for
connection with the self-boiled solution.

Thoroughness and Timeliness in Application

The desired results from dusting or spraying will not be obtained fu
unless the applications are made in a thorough manner, and as close
possible to the time called for in the schedules. The commercial gro
realizes this, and his treatments for the curculio become one of
major orchard operations. On the other hand, it is a common pract
for the home orchard owner to neglect or delay making an applicati
with the result that applications are not made at the time when th
will do the most good.

In spraying a tree the operator should start on the side of the t
away from the spray machine and work around the tree, being care
to cover the tree, and particularly the fruit, entirely. The hauling

r to the spray outfits in the orchard will very often facilitate spray-
Competent supervision of spraying is essential to see that the mix-
are properly prepared and thoroughly applied.
dusting, the machine should be driven down each tree row, so that
perator can dust the near side of each tree. Unsatisfactory results
isually obtained when an effort is made to dust two or three rows at
same time, or to give the treatments when there is much breeze.
y local conditions at the time of dusting will govern the exact
ods to be employed, but one should aim to coat the tree lightly and
lop it in a cloud of dust.

Treatment of the Edges of Orchards

ne commercial peach grower is familiar with the fact that the edges
ne orchard nearest the woods are, as a rule, more heavily infested
curculios early in the season than the center or the edges of the
ard which are more distant from wooded or waste land. In case of
y infestation in any orchard, it would seem advisable to make an
spray or dust application upon the first four to six rows around
dge of the orchard, the object being to poison the beetles just after
come out of winter quarters. This extra application should be
e four or five days after the second application of the regular
dule. In the case of spray, it should be mixed according to the
nula of the first and second applications. In dusting, use the regular
nula.

is extra or supplementary application is recommended only where
grower has experienced difficulty in securing adequate curculio con-
where wet weather has interfered with previous treatments, or
e burning over of adjacent waste and wooded lands cannot be prac-
. It should be a relatively light application, for a heavy treatment
most sure to effect burning by the time the two later applications
ne regular schedule are made.

Picking Up Dropped Fruit

e have mentioned above that many worms develop in the small
ped fruit in spring, and that these worms transform to beetles in
ground. About thirty days after the worms enter the ground they
me beetles of another brood, which sometimes attack the late varie-
of fruit just before they begin to ripen. This habit suggests the
rtance of picking up all dropped fruit, especially those found under
trees during the latter part of April and the entire month of May.
commercial peach growers of the sandhills realize the importance
his control measure and practise it regularly, though the work is
sionally carried out somewhat carelessly, with rather indifferent
lts.

In 1922 a bushel of drops containing 5,338 fruits yielded 3, worms—an infestation of 56.43 per cent. In 1923 six different bus of drops showed that 33, 35, 38, 79, 113,* and 120* per cent of the dr respectively, contained worms. These figures give some idea of the portance of picking up dropped fruit, so that the numbers of curcu may be reduced.

The drops should be picked up at least three times every two w during the latter part of April and the early part of May. The wo do not remain in the drops more than a week, as a rule, after the fr have fallen, and frequently only four or five days. Picking up of drops should always precede cultivation, if it is intended to cultiv the orchard. Under no circumstances should the drops be covered v soil, as may be done in cultivating.

In disposing of the drops, they should be buried in a quicklime with alternate layers of drops and lime. Boiling the drops may be isfactory, but caution is urged not to allow the drops to stand aroun containers, so that the worms can escape to the ground before the dr can be poured into boiling water.

The cost of picking up of drops has been found to be comparativ small, when the benefits derived are considered. This part of curcu control will be found of value in the home orchard as well as the c mercial orchard. It not only reduces the number of curculios by p venting their development, but in certain seasons it might lessen amount of brown rot as well.

Orchard Cultivation and the Destruction of the Curculio

It is the present practice of fruit growers in the sandhill section cultivate frequently throughout the season. This orchard operation only benefits the trees, but is believed by the growers to destroy the la and pupæ of the curculio while in their cells in the ground. Our ob vations indicate that comparatively few larvæ and pupæ of the curcu are destroyed by cultivation in the sandy type of soil characteristic this sandhill section; at least, the number killed by cultivation is c siderably smaller than is generally supposed by fruit growers.

During the months of May, July, and the first half of August, wh the larvæ and pupæ of the curculio are found in the soil in numb cultivation of the soil will probably be of some assistance in controll the curculio. It would seem, however, that we could not recommen cultivation of the orchard solely for the purpose of destroying the wor and pupal stages of the curculio.

* There were more worms than drops, some drops containing more than worm.